Extreme Heat in a Changing Climate

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ESSM Community Workshop
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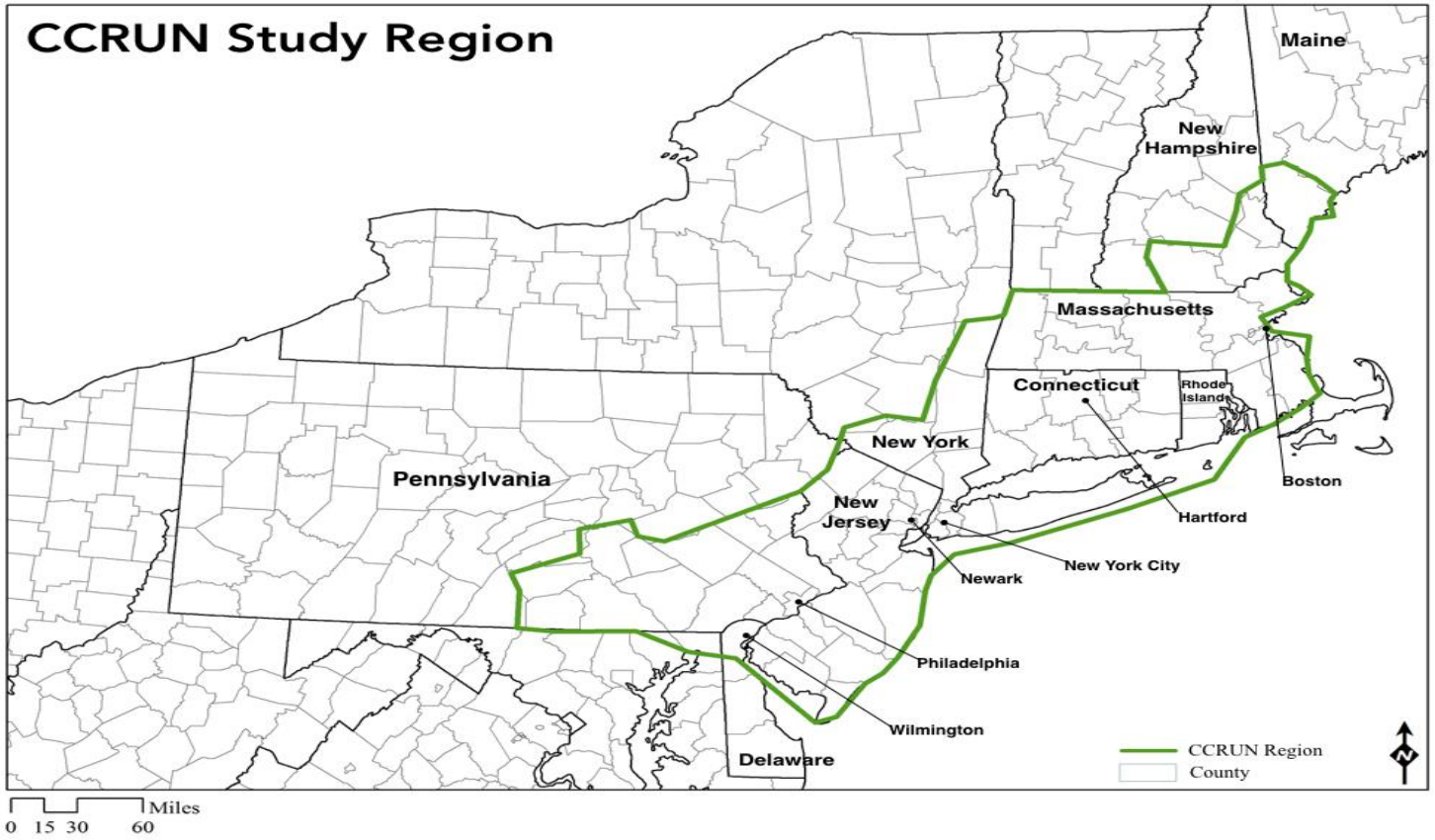
NOAA RISA Program

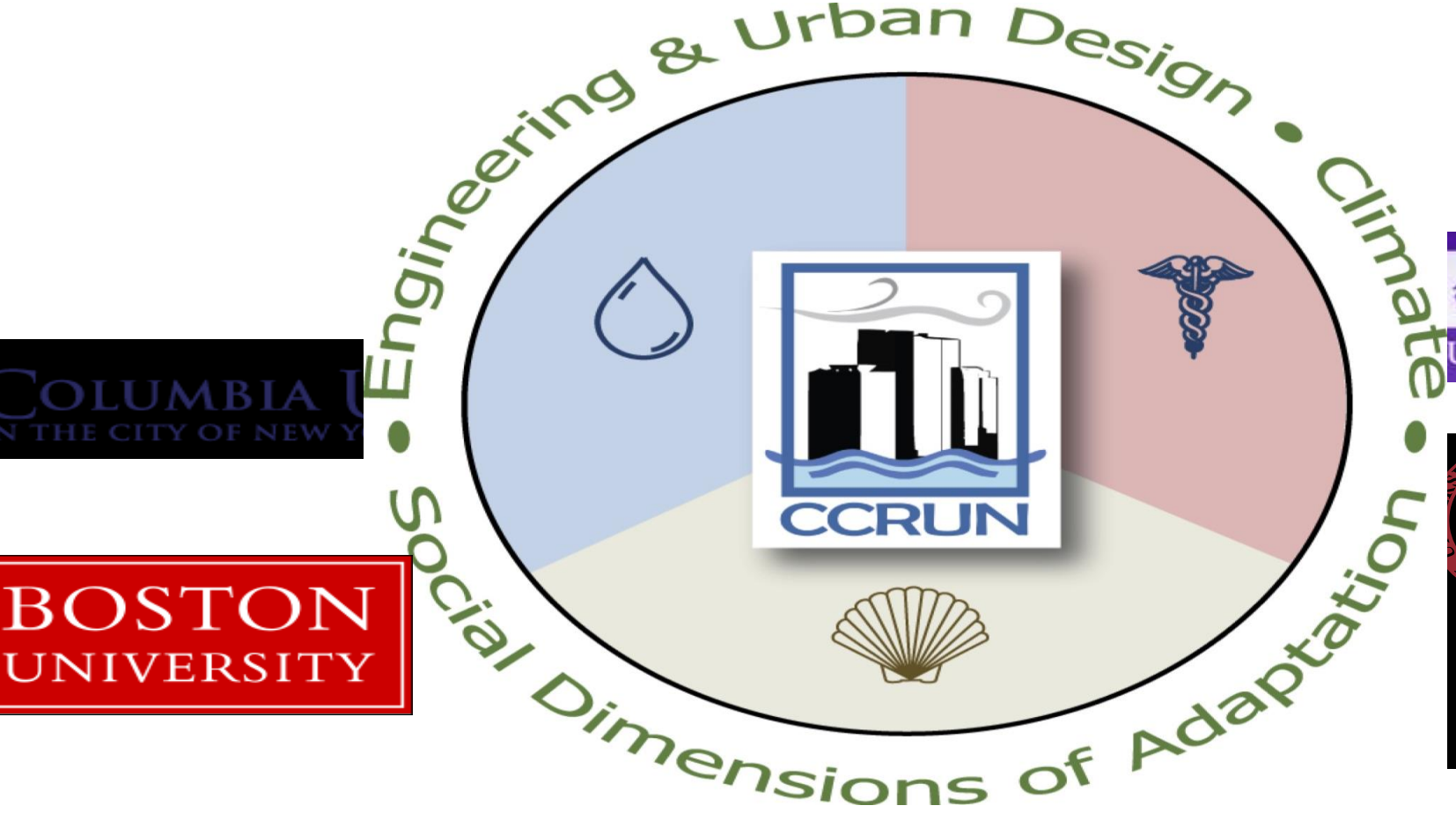
- NOAA Regional Integrated Sciences and Assessments (RISA) Program
  - Supports eleven regional teams across the country that help expand and build capacity to climate variability and change

- The Consortium for Climate Risk in the Urban Northeast (CCRUN)
  - The only RISA team with principal focus on urban settings.



CCRUN geographic domain defined by metropolitan area counties

Consortium for Climate Risk in the Urban Northeast



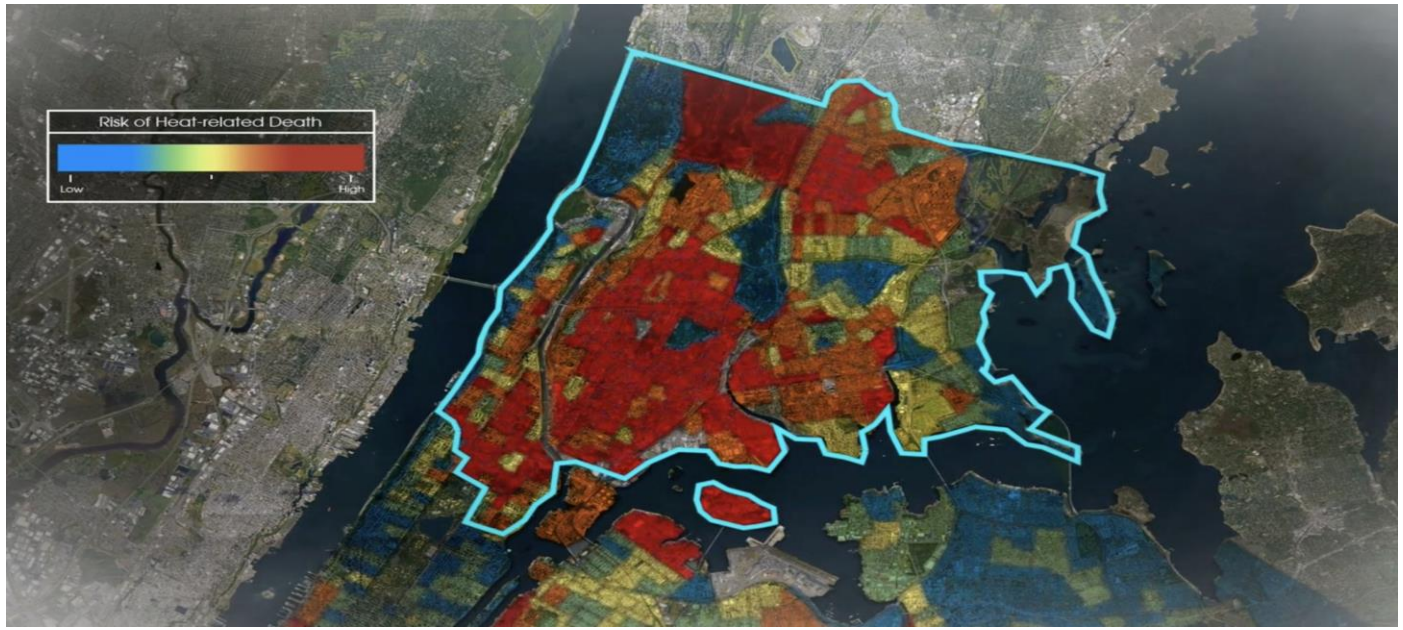
A partnership of six universities

Three research areas, three cross cutting themes

CCRUN Helps New York City Prepare for Extreme Heat

1. Identify stakeholders
2. Conduct co-generated research
3. Integrate research into adaptation planning
4. Work at the neighborhood level to advance knowledge and share results

NOAA Data informs CCRUN Research Teams



CCRUN researchers developed a social vulnerability index for New York City, identifying neighborhoods vulnerable to high temperature extremes

For a video documenting CCRUN's heat-health work, visit NOAA Climate's Youtube!

Recent CCRUN Heat-Health Publications

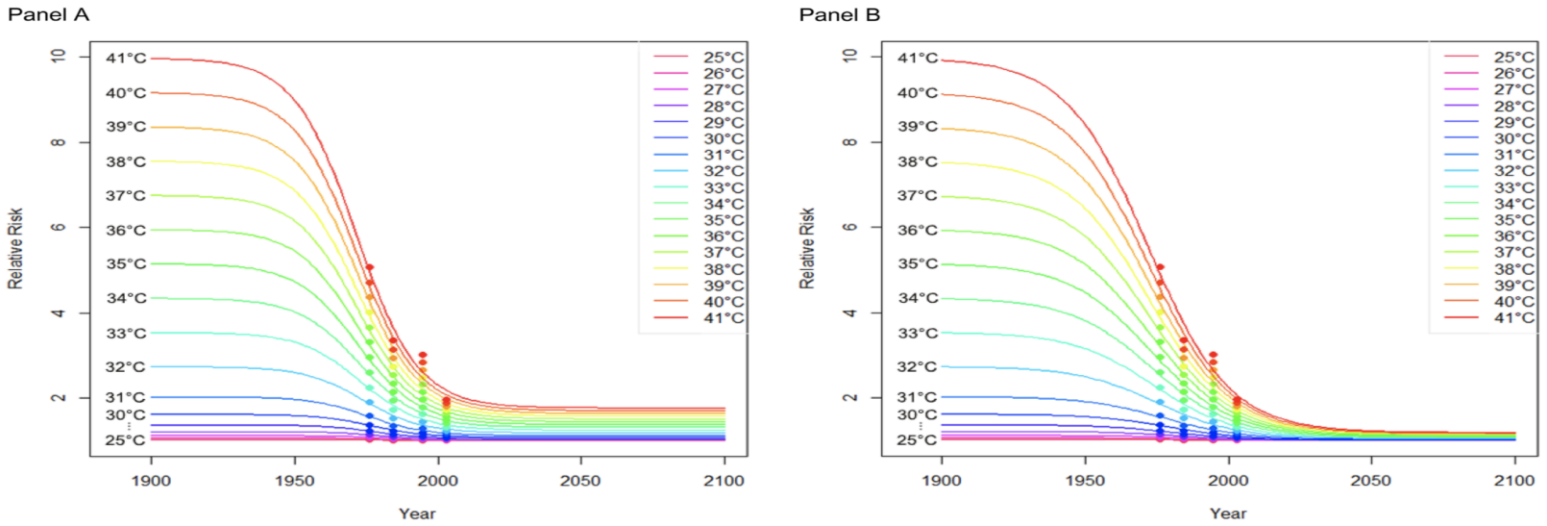


Figure 1. Temperature-specific mortality curves for New York City, 1900–2100. (*A*) Adaptation model assumes that temperature-specific relative risks will decrease by an additional 20% ("low adaptation") between 2010 and 2100 compared with the 2000s. (*B*) Adaptation model assumes that temperature-specific relative risks will decrease by an additional 80% ("high adaptation") between 2010 and 2100 compared with the 2000s. Points represent the relative risks (RRs) calculated using the distributed lag non-linear model (DLNM) for each temperature for the 1970s (1973–1979), 1980s (1980–1989), 1990s (1990–1999), and 2000s (2000–2006). RRs were calculated for June–September using a model with a quadratic spline with 4 degrees of freedom and 22°C as a reference temperature.

- Kinney, P. L. (2018). Temporal Trends in Heat-Related Mortality: Implications for Future Projections. Atmosphere, 9(10), 409.

- Nayak, S. G., Shrestha, S., Kinney, P. L., Ross, Z., Sheridan, S. C., Pantea, C. I., . . . Hwang, S.A. (2017). Development of a heat vulnerability index for New York State.

- Petkova, E. P., Vink, J. K., Horton, R. M., Gasparrini, A., Bader, D. A., Francis, J. D., & Kinney, P. L. (2017). Towards More Comprehensive Projections of Urban Heat-Related Mortality: Estimates for New York City under Multiple Population, Adaptation, and Climate Scenarios. Environmental Health Perspectives, 125(1), 47-55.

The Workshop on Correlated Extremes will take place on Columbia University's Morningside Campus on May 29-31, 2019. It will be comprised of a blend of invited talks and abstract submissions, with significant effort aimed at generating discussion among the attendees.

How do we Define a Compound/Correlated Extreme Event?

- **Multivariate**
- **Concurrent**
- Sequential

Motivation for Studying Extreme Humid Heat

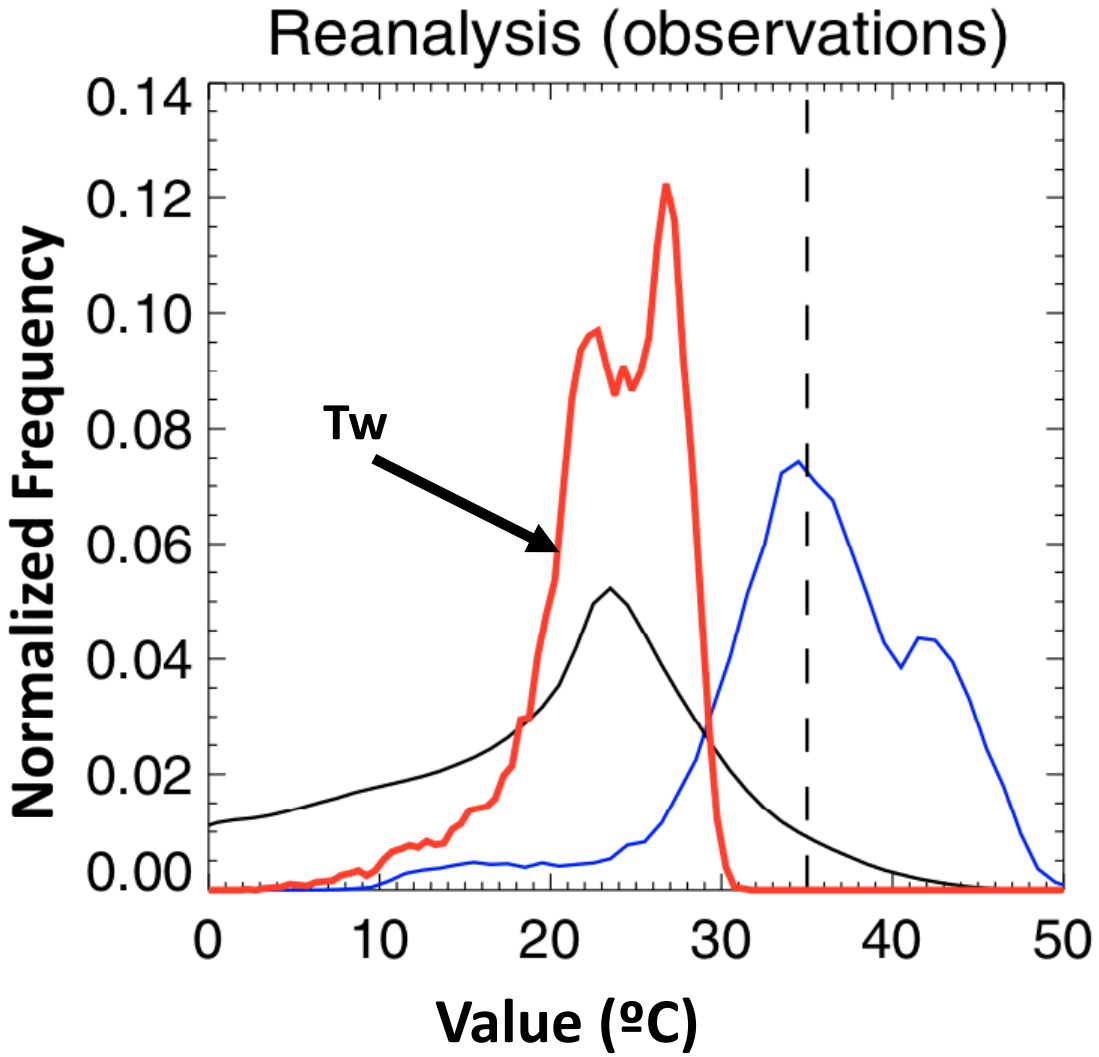
Imminent health concerns

- Humid heat is a close proxy for physiological heat stress
  - *many medical, military, athletic, economic ramifications*

- ~35ºC is the **physiological survivability limit**
  - *above this value, homeostasis cannot be maintained without artificial cooling, even under idealized conditions*

- Severe impacts occur at levels which are mostly relative, but become absolute approaching Tw=35ºC
  - *vulnerability can be individual (acclimation, health status) or societal (technology, culture)*
    → importance of knowing regional context

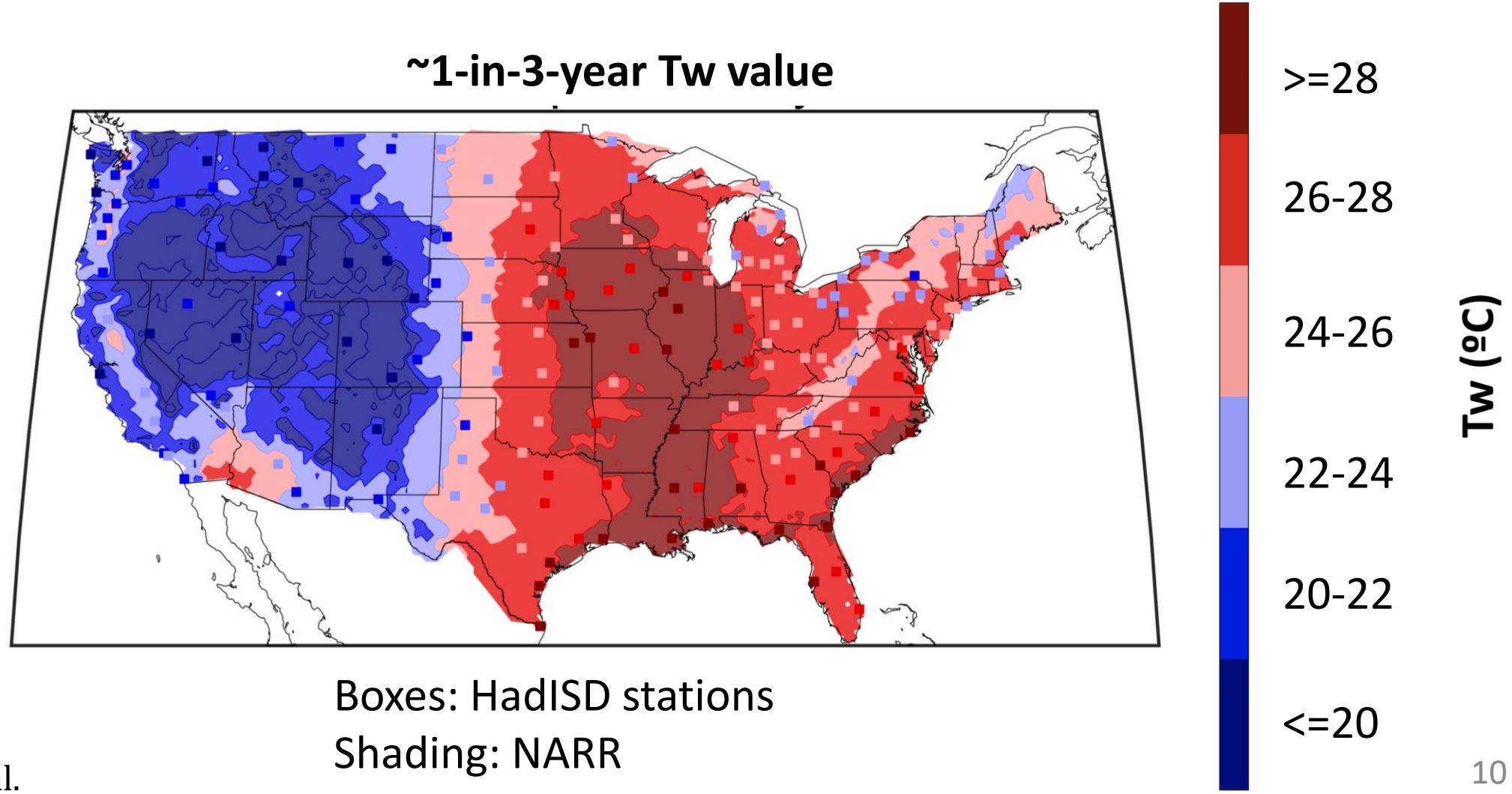
Motivation



-->Tw distribution has a very thin right tail

Sherwood & Huber 2010

U.S. extreme-Tw regional pattern closely matches moisture

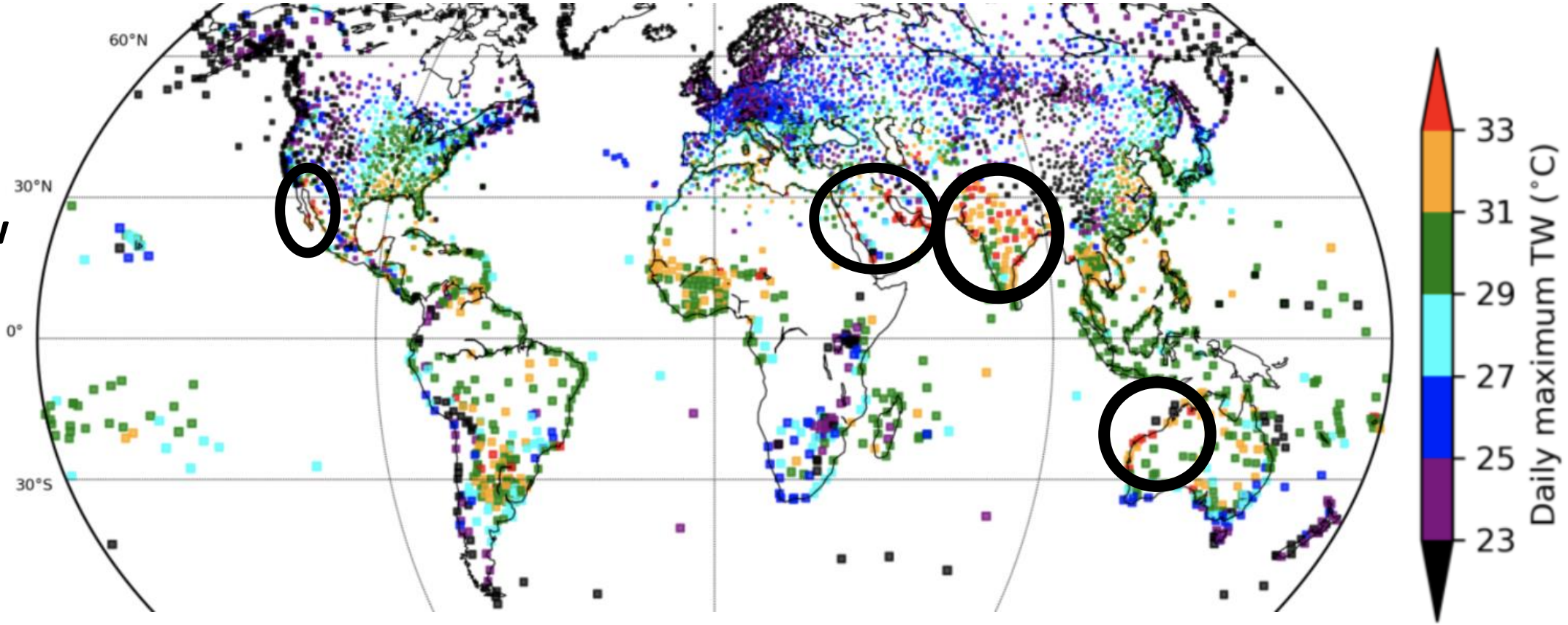


Boxes: HadISD stations
Shading: NARR

Raymond et al. 2017

Globally, the highest Tw values occur along subtropical coastlines

All-time maximum Tw (1979-2017) from HadISD

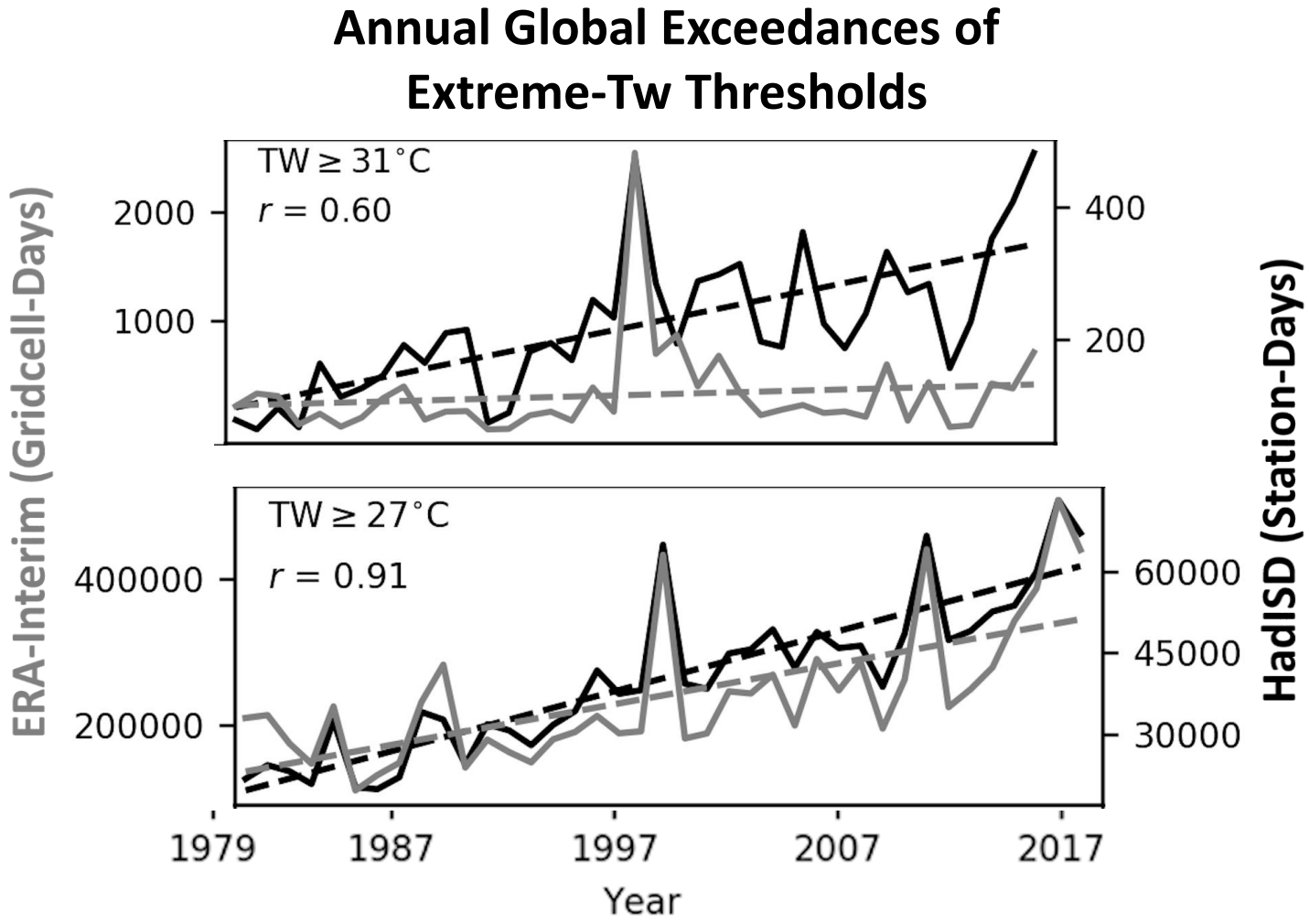


Raymond et al. (in review)

Changes in the *most intense* humid heat

Strong and robust trends

- More than a doubling since 1979
- Good agreement between stations and reanalysis in trends of lower percentiles



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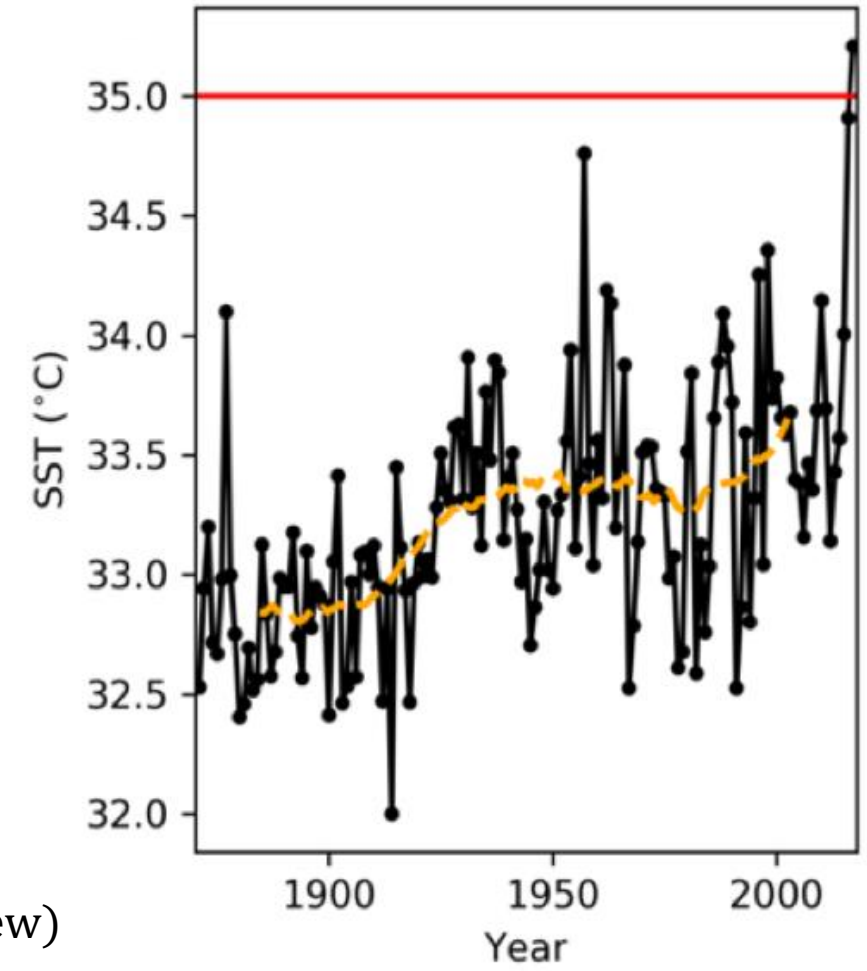
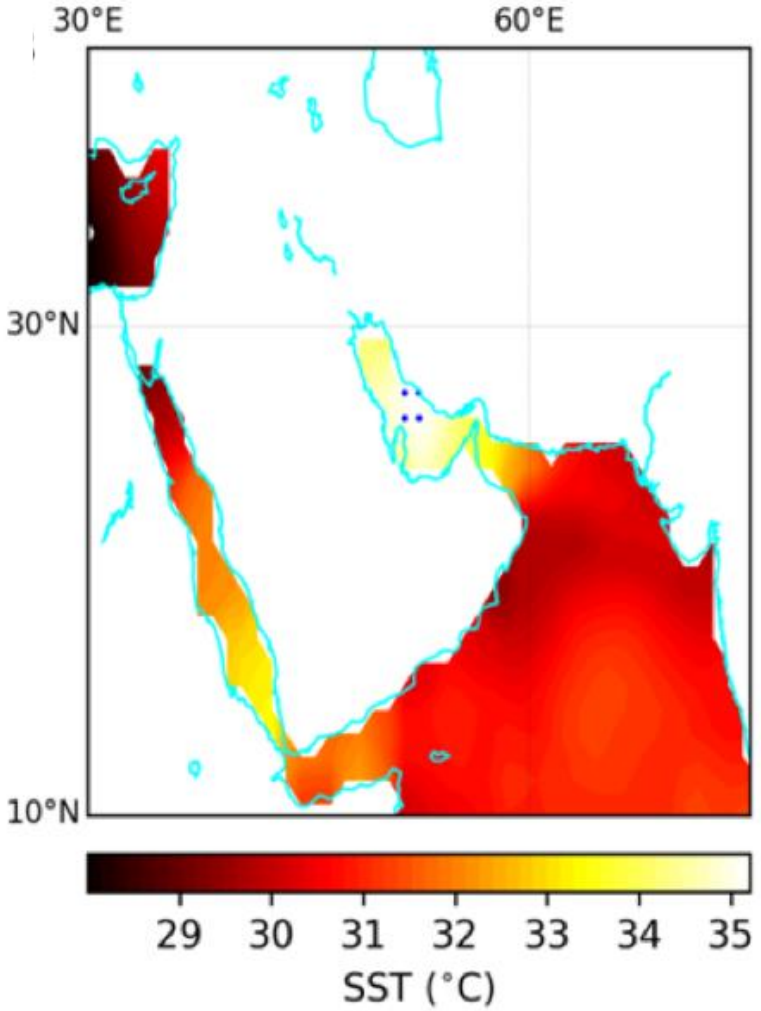
Global Annual-Max SST

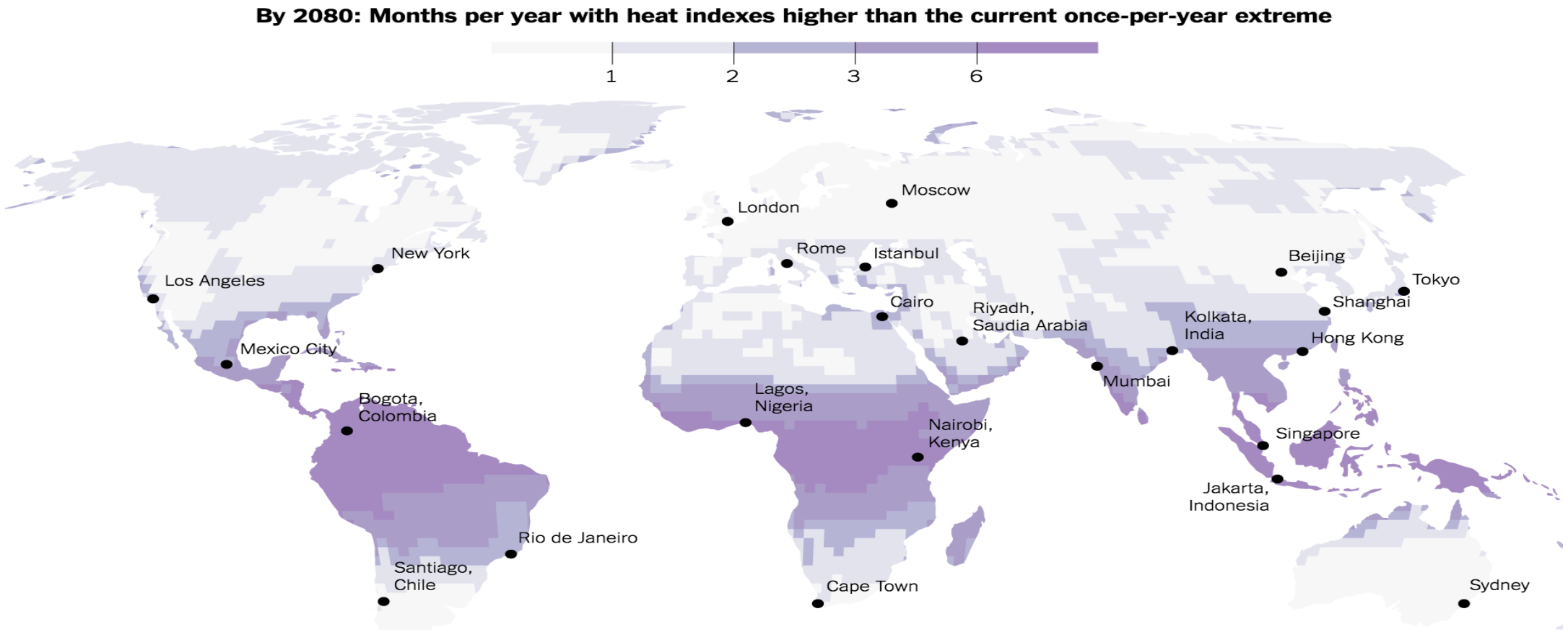


Gridcell All-Time-Max SST



Raymond et al. (in review)

Outdoor Labor and Recreation



Extreme humid heat will become a regular occurrence in much of the world, with large implications for human safety, productivity, and energy consumption

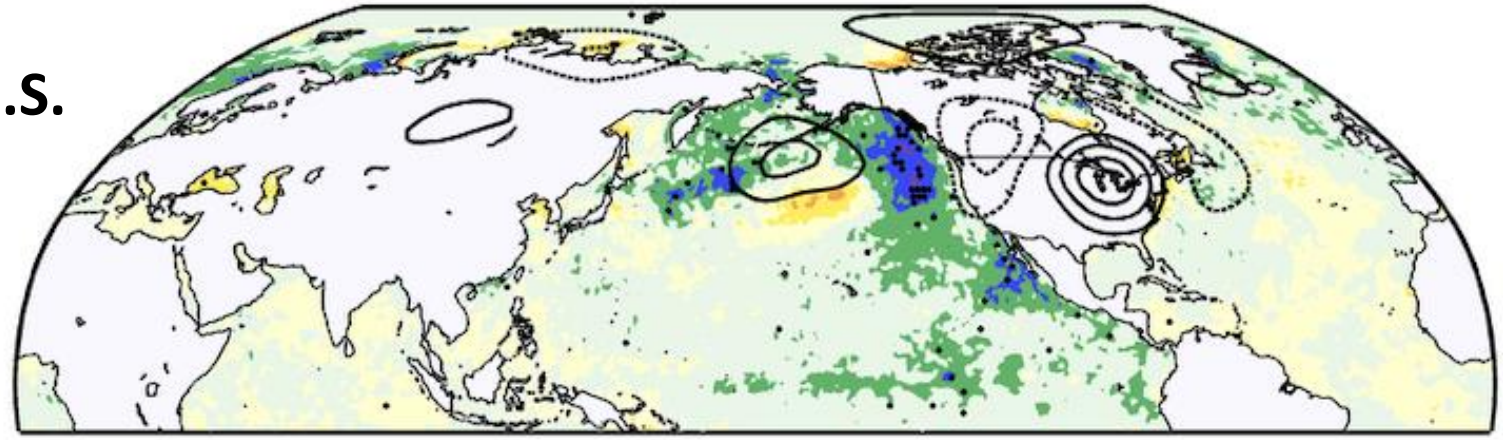
Source: New York Times, Oct. 11, 2018

Qualitative differences in predictive factors between regions

Composite anomalies of **z500** (20-m intervals, negative dashed) and **SSTs** (shading, stippling at 95% significance)

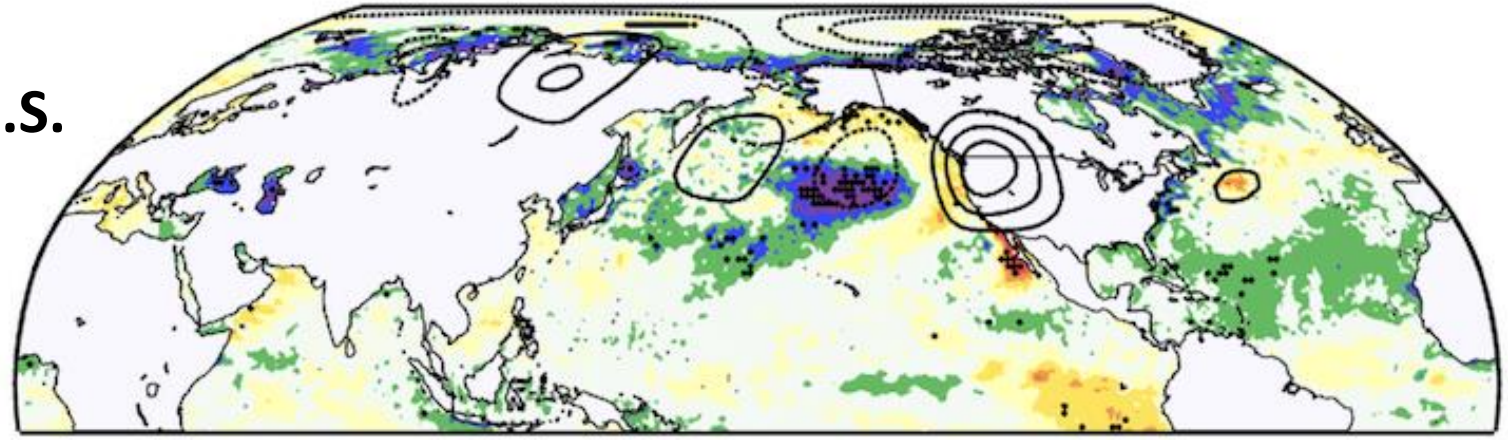
Midwest U.S.

Local SSTs don't matter →



Southwest U.S.

Local SSTs do matter →



Raymond et al.

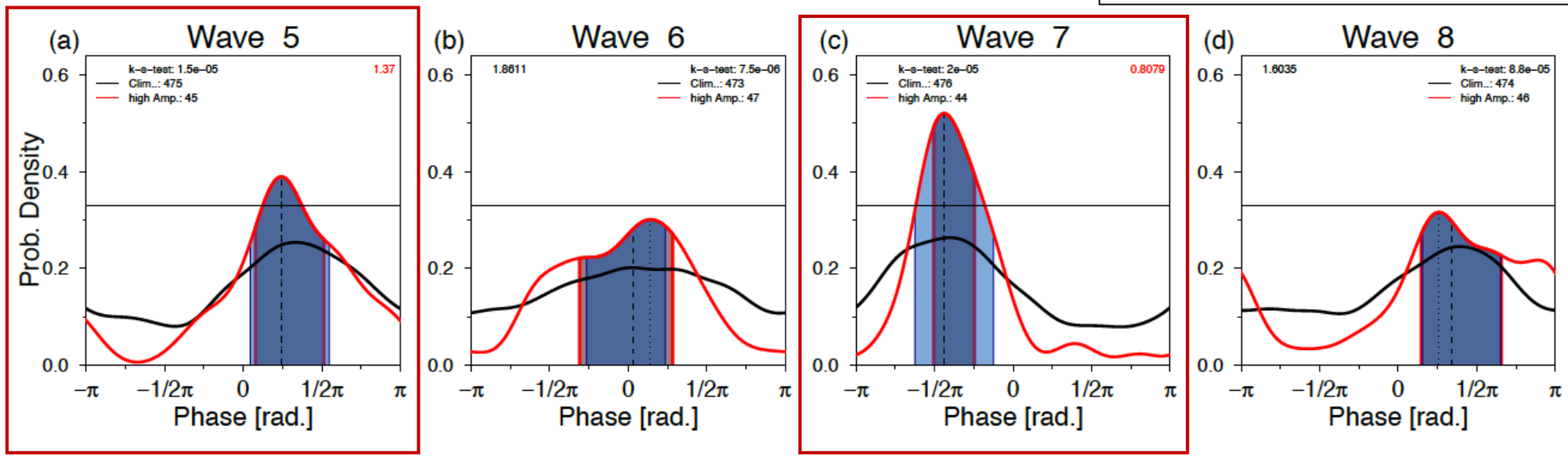
Recurrent Rossby Wave Patterns

Probability density functions of wave phases
(weekly means, JJA, 1979-2018, NCEP.NCAR)

High Amp waves (> 1.5std, red) vs Normal Amp. waves (<1.5 std).

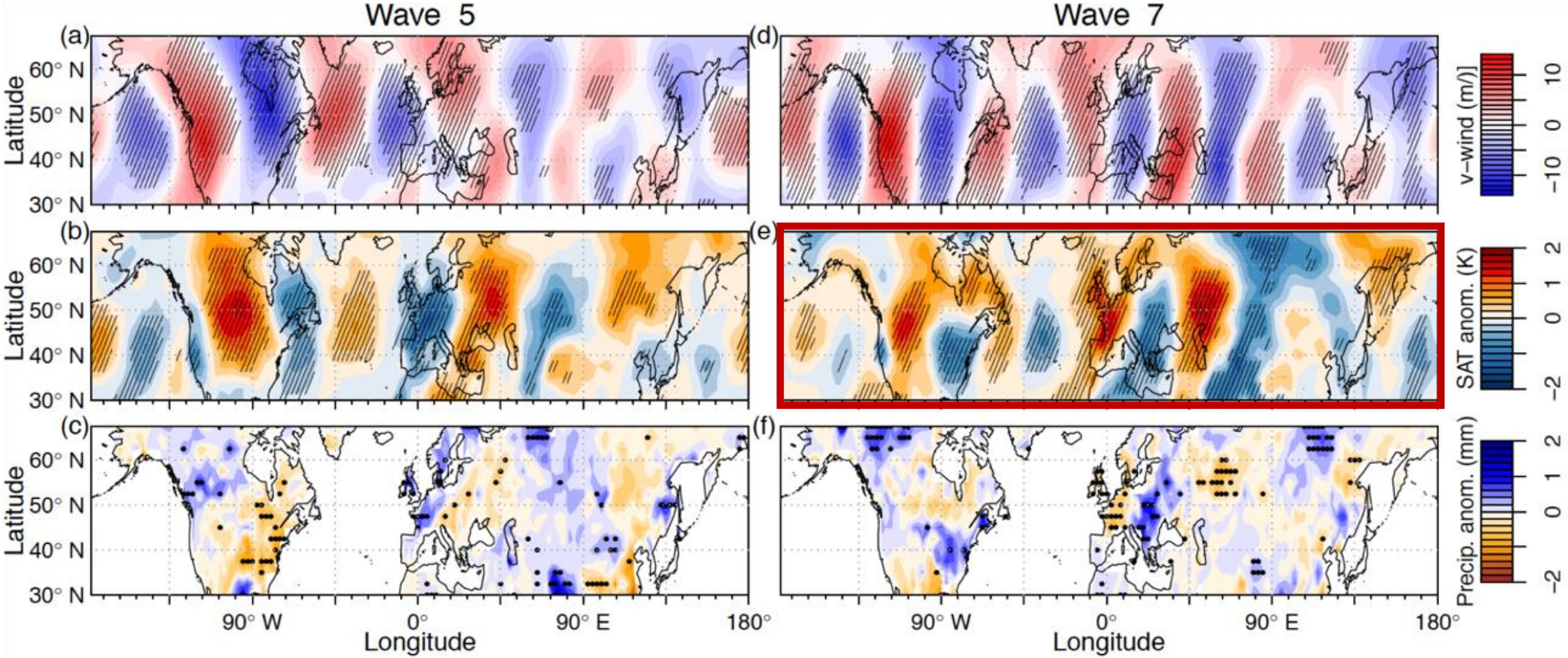
$$\psi = A\sin(k\lambda - \varphi)$$

ψ: Wavefunction, A: Amplitude, k: zonal wavenumber
λ: Longitude, φ: Phase



Kornhuber et al. *Nature Climate Change* (2019)
Kornhuber et al. *Journal of Climate* (2017)

Recurrent Rossby Wave Patterns



Prominent examples:

Russian heatwave 2010 **European Floods** 2002, 1997, 2013

US Heatwaves 1984, 2011

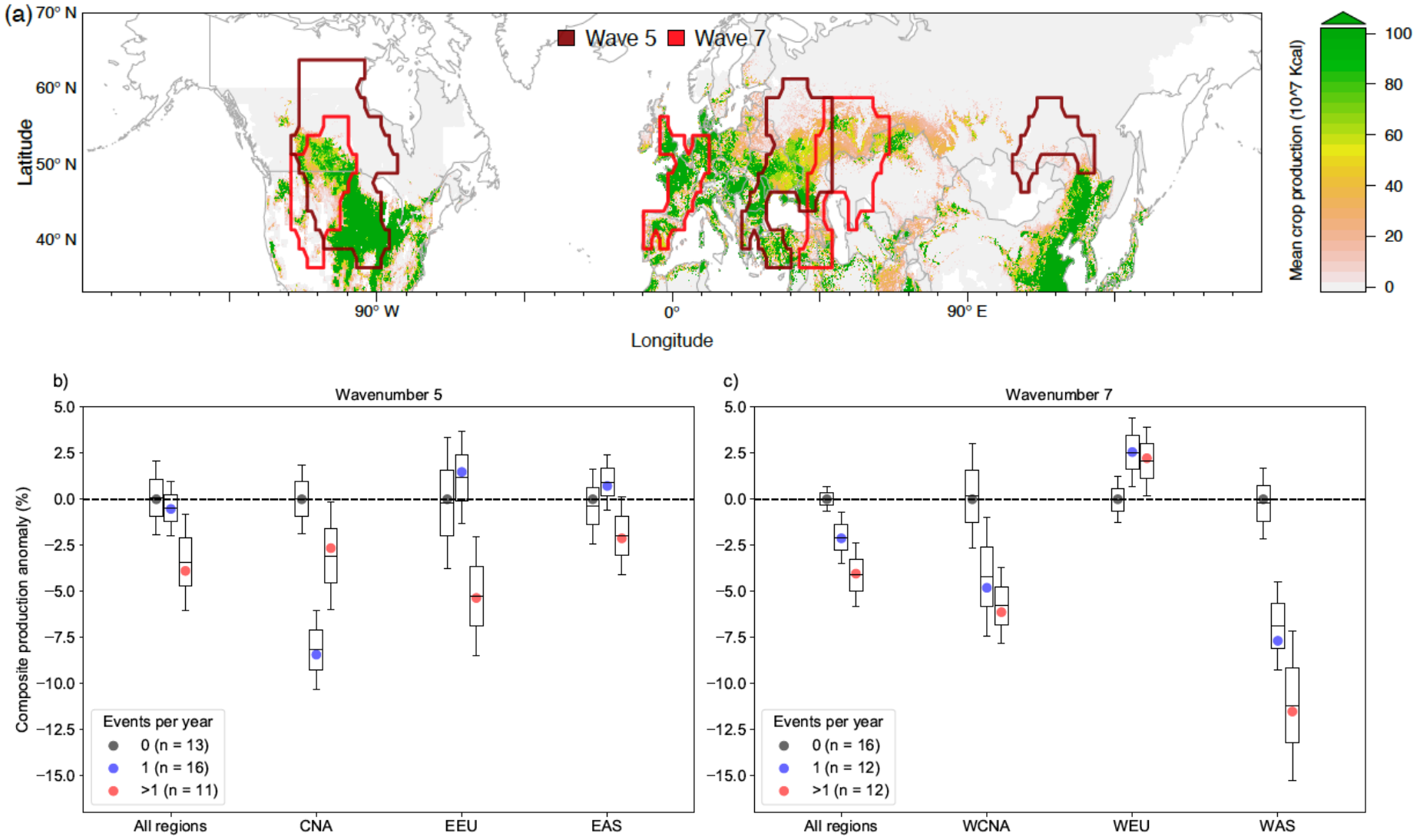
Prominent Examples

European heatwaves 1994, 2003, 2004, 2006, 2009, 2015, 2018, 2019

US heatwave 2012

Kornhuber et al. *Nature Climate Change* (in press)

Impacts on Crop Production



Kornhuber et al. *Nature Climate Change* (in press)

Future Change & Drivers

Do amplified waves occur more often and can this be linked to the change in temperature gradients?

What is the anthropogenic influence and what can we expect for the future?

How do Models perform?

Legal Implications of Extreme Event Attribution

- Assessments are now being conducted of historical emissions of fossil fuels and other radiatively important agents by nations, industries, and companies
- Methods have also been developed for attributing mean changes in climate, individual events, and impacts to human activity or other drivers
- More and more lawsuits are being filed against both emitters and those who failed to consider climate risk and/or adapt
- Whether or not these lawsuits prove successful, there are questions of reputational risk, with possible feedbacks on the regulatory environment

This conference will address a range of issues facing coastal communities in the United States and around the world as sea levels rise and coastal flooding becomes more frequent and intense. This conference will bring together thought leaders on this topic to advance the science and policy dialogue. The topics will be of interest to academics, planners, practitioners, and industry representatives from sectors such as real estate and insurance.

http://adaptation.ei.columbia.edu/conference/at-what-point-managed-retreat-conference/